PROTECTION
of Buildings and Farm Property
FROM LIGHTNING

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U. S. DEPARTMENT OF AGRICULTURE

EXPERIENCE has shown that the odds are 12 to 1 in favor of a building equipped with lightning rods escaping damage as compared with an unrodded building.

Lightning rods protect not only buildings but also stock, property, and persons.

The purpose of this bulletin is to give practical directions for the installation of lightning rods.

The following are safety rules for persons exposed to a thunderstorm:

Do not go out of doors or remain out during thunderstorms unless necessary. Stay inside a building where it is dry, preferably away from fireplaces, stoves, and other metal objects if the building is not protected by rodding.

If there is any choice of shelter, choose in the following order:

1. Large metal or metal-frame buildings or buildings that are protected from lightning.
2. Large unprotected buildings.
3. Small unprotected buildings.

In all cases it is best to stay away from open doors and windows.

If remaining out of doors is unavoidable, keep away from:

1. Small sheds and shelters in exposed locations.
2. Isolated trees.
3. Wire fences.
5. Hilltops and large open spaces.

Seek shelter in a cave, a depression in the ground, a deep valley or canyon, the foot of a steep or overhanging cliff, in dense woods, or in a grove of trees, but beware of floods and falling trees and branches.

The occupants of an automobile having a metal body are practically immune from injury by lightning.

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PROTECTION OF BUILDINGS AND FARM PROPERTY FROM LIGHTNING

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Contents

DAMAGE BY LIGHTNING

LIGHTNING does some apparently freakish things, but its actions are usually explainable. The better we understand its cause and its character the better we can protect ourselves and our property from its destructive force. The Bureau of the Census shows that about 400 persons are killed and 1,000 injured annually in the United States as a result of lightning strokes. Although this number may seem large, actually it is small in comparison with the number of persons killed in other kinds of accidents.

Lightning damage to property and livestock is heavy. In Iowa, where a record of lightning damage on farms has been kept, 1,304

[1] Appreciation is extended to the National Bureau of Standards, National Fire Protection Association, U. S. Forest Service, and Rural Electrification Administration for reviewing the manuscript and making valuable suggestions; and to the General Electric Co., Westinghouse Electric Corp., the Civil Aeronautics Administration, and Iowa State College of Agricultural and Mechanic Arts, whose information was drawn upon in the revision of this bulletin.

farm fires were caused by lightning in the years 1930 through 1947 (table 1). The total damage was $2,919,850, or an annual loss of $162,214. These figures do not include losses of livestock or of other personal and real property.

To obtain the greatest degree of protection from lightning it is necessary to have concise, practical, and up-to-date information and definite specifications for choosing and installing equipment.

TABLE 1.—*Record of rural fires in Iowa by years, 1930–47* [1]

Year	Fires caused by lightning				Number of rural fires from all causes
	Rodded buildings		Unrodded buildings		
	Number	Damage	Number	Damage	
		Dollars		*Dollars*	
1930	6	25, 250	96	215, 652	1, 360
1931	2	3, 530	85	210, 750	1, 208
1932	9	25, 025	70	135, 403	1, 234
1933	2	7, 850	66	104, 960	1, 115
1934	8	31, 400	71	112, 129	1, 254
1935	1	1, 550	40	62, 403	652
1936	4	5, 850	105	176, 715	1, 473
1937	4	13, 775	68	95, 133	867
1938	11	72, 685	92	120, 322	880
1939	9	9, 440	66	120, 787	1, 056
1940	3	9, 830	49	85, 795	839
1941	5	9, 750	59	100, 828	681
1942	5	18, 700	50	94, 244	519
1943	7	34, 281	67	143, 418	548
1944	8	23, 835	64	178, 276	424
1945	5	13, 615	60	148, 339	602
1946	12	46, 325	56	324, 414	496
1947	3	28, 150	36	109, 441	470
Total	104	380, 841	1, 200	2, 539, 009	15, 678

[1] Data obtained from Henry Giese, research professor of Agricultural Engineering, Iowa State College of Agriculture and Mechanic Arts, Ames, Iowa.

The use of metal conductors to protect buildings from lightning damage followed Benjamin Franklin's kite experiment in 1752, and since that time scientists have advocated the protection of houses, barns, and other property from lightning. Experience has proved that when the equipment is carefully selected and installed the protection afforded is almost complete.

The specifications found on pages 28 to 31, inclusive, and the text preceding them, which describes the methods and materials employed, should help the prospective buyer make an intelligent choice of protective equipment. It is advisable to get competitive bids and deal only with well-established, reputable firms. Underwriters Master Label service is available for materials and for completed installations. Labels are issued only upon inspection by Underwriters Laboratory inspectors.

NATURE OF LIGHTNING

Static electricity consists of charges of two kinds, positive and negative. A charge of one kind of electricity will repel another charge of the same kind and attract one of the opposite kind. Two charges of electricity, one positive and one negative, in the same vicinity will exert a strong attraction on one another and tend to unite. We may think of this attraction as exerted along lines of force between two charges. If you have stood under a fast moving belt and felt your hair rise, you have sensed these lines of force. Of course, the pull of attraction becomes less as the charges are separated, just as the pull between the unlike poles of two magnets becomes less as they are separated. On the other hand, the larger the charges the greater will be the pull between unlike charges for a given distance of separation.

An interesting thing about these charges is that they always appear in pairs. As soon as an accumulation of one kind of charge begins to form, another of the unlike kind will also start forming in some nearby region. The amount of energy per unit charge that would be required to move electricity from one point to another through space is known as the difference of potential between the points and is measured in volts.

The charges in summer thunderstorms often accumulate in large quantities and develop potential differences of very high voltage between the base of cloud and the earth. Both kinds of charges accumulate in thunderclouds and in the earth in the vicinity of the clouds. For example, in the base of such clouds usually large negative electrical charges collect, and these induce large positive charges in the earth beneath the cloud. The cloud base and earth beneath act just like a charged electrical capacitor (condenser) with air as the dielectric, or insulator.

Examples of small electrical capacitors are those used in radio receivers and across the breaker points of your automobile distributor. In these capacitors the insulating dielectric is made of paper and the charges, positive and negative, are held in metal foil on either side. When the paper can no longer keep the two charges separated, it is punctured by the rushing of the negative charges toward the positive. This represents a wave of electrical current. Because of the resistance to the flow of electricity, heat is produced. The sudden release of heat produces a sharp snap.

When the potential gradient along the lines of force between the accumulations of negative and positive charges becomes so intense that the insulating characteristic of the air breaks down, the air is punctured, and negative charges rush toward the positive ones in vast numbers, while a counterflow of positive charges tends to occur in the opposite direction. The rush of electricity between the charges heats the air to incandescence. This results in a giant spark called lightning.

As a rule an accumulation of negative charges occurs near the base of the thundercloud, and an accumulation of positive charges occurs both in the upper part of the cloud and in the surface of the earth and its projecting objects beneath the base of the cloud (fig. 1). Such projecting objects include trees, buildings, poles, steeples, and wires. Fine, rapidly moving streamers of negative charges develop along the lines of force between cloud and cloud, or between cloud and earth.

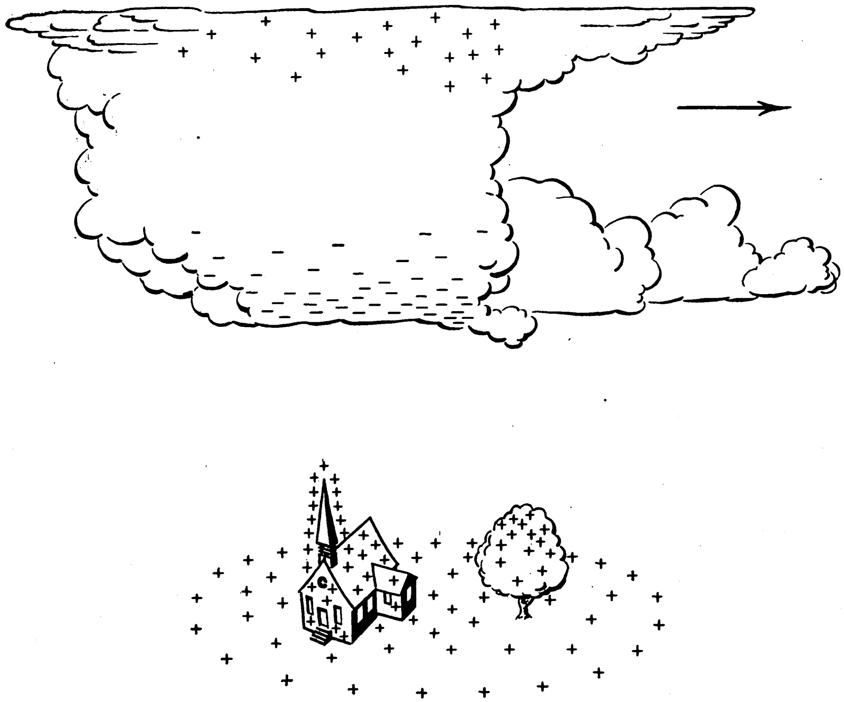

Figure 1.—**Section through a thundercloud from front to back. The arrow indicates the direction of travel. The negative charges in the lower part of the cloud are accompanied by an area of positive charges in the earth and in other parts of the cloud.**

After the air insulator breaks down, i. e., is punctured, it becomes a very much better electrical conductor at this point, and the accumulation of charges follows along this path of lower resistance.

There is no sure way of foretelling where these paths of lower resistance will occur, so there is no sure way of knowing where lightning will strike. The regions of greatest voltage gradient along the lines of force will be centered at the tips of sharp-pointed, tall objects, such as vertical rods, flagpoles, steeples, roofs of buildings, and trees. Lightning is therefore more likely to strike one of these points than it is to strike a large flat surface at the same or lower elevation.

WHEN AND WHERE LIGHTNING OCCURS

Over most of the United States electric storms are more frequent in late spring and in summer than during other seasons. They develop most frequently on hot, humid afternoons, although in the north-central part of the United States they may develop more frequently in the evening. Most strokes to earth occur during the first part of the storm.

The Weather Bureau for many years has kept a record of thunderstorms in the United States and the approximate annual frequency of such storms is known. A map of the United States indicating the average number of thunderstorms per year is shown in figure 2. Storms vary considerably in duration, severity, and number from

year to year. The numbers on the map are averages for the years 1904 through 1943. A larger proportion of lightning strokes occurs within clouds than between clouds and ground. Toward the end of the storm the discharges are more likely to take place within clouds or from cloud to cloud.

An individual building in town stands less chance of being struck than one in the country. This is because there are so many other buildings of about the same height nearby in town. A building, tree, or flagpole standing alone is most susceptible. For that reason it is advisable not to take shelter under a tree during a thunderstorm. This is particularly true if the tree stands alone. A wire fence will conduct electricity for a considerable distance (probably as much as 2 miles) if it gets struck or if it is fastened to a tree that gets struck. Many cattle are killed each year when standing under trees or along

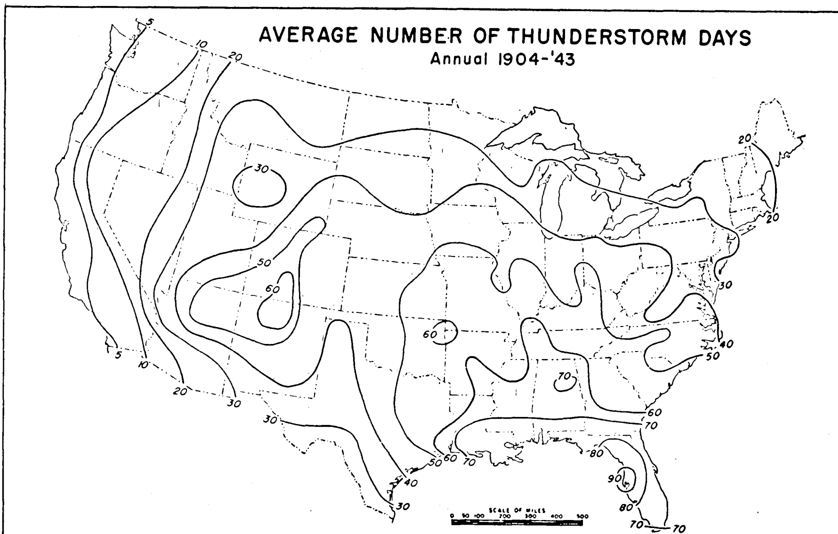

Figure 2.—**Map of the United States showing thunderstorm days per year. Each line passes through areas having the same average number. Areas between the lines experience an average number somewhere between that of the lines; thus most of Missouri is in a region having between 50 and 60 thunderstorms per year.**

wire fences. Wire fences should not be attached to buildings. It is a good idea to connect wire fences to the ground (preferably moist earth) by using electrical conductors every few rods. Metal posts will do a fairly effective job of grounding except in very arid regions.

WHAT HAPPENS WHEN LIGHTNING STRIKES

Although electricity generally travels along the path having the lowest resistance, some of the discharge will travel along all the paths that lead in the direction it is moving. When an appreciable electric current flows along a path of high resistance there will be considerable heating. The more resistance the more heating. When the current passes along a copper or other good electrical conductor excessive heating does not occur, provided the conductor is large enough.

The current in a flash of lightning may be a few thousand amperes or it may reach values exceeding 200,000. Great pressures are set up around the lightning's path. If the current passes through a dry timber the wood is often shattered into small bits. When lightning strikes a live tree, some of the sap is turned almost instantly to steam at high pressure. The pressure bursts the tree, splitting the wood and blowing off the bark.

If hay, straw, or other highly combustible material is in contact with an object heated to high temperature or if it forms part of the path for the current, it may be heated to the ignition temperature. In the latter case it may be heated through the whole depth along the path of the stroke. For this reason fires started by lightning are often widespread by the time they are discovered.

If a low-resistance path or conductor is provided most of the discharge will flow through this path rather than through the building, tree, flagpole, or other tall object. The steel framework of buildings provides excellent paths for electricity. If the steel members are effectively grounded, such buildings are safe. The Empire State Building in New York City has been struck by lightning many times with little or no damage to the building and no inconvenience or discomfort to the occupants. The steel is a better conductor than most other materials in the building. Practically all of the electric current follows it to ground instead of injuring the building or occupants. The steel or metal body of an automobile or airplane will give the same kind of protection. A steel bed is also a safe place provided an arm or a leg of the occupant does not hang over near a radiator or water pipe.

THUNDER

When a flash of lightning is intense it heats the air, which expands very rapidly. Sound waves are set in motion in about the same way as when a gun is fired. When a gun is fired a loud boom is heard. That is because the expansion of air occurs in one place. If there are surfaces from which sound waves may be reflected, echoes may be heard. In the case of lightning, the expansion occurs along a long, sometimes zigzag, line. The expansion takes place along the whole line practically at one time, but more time is required for the noise to reach the ear from the distant end of the flash than from the near end. Hence a long roll of thunder may be heard. If there are echoes, these may add to the noise.

Not every flash of lightning is accompanied by a clap of thunder. Strokes that produce little or no thunder generally have little disruptive, explosive effects, but they may cause fires because of a relatively long continuation of substantial electrical currents.

Thunder is not known to cause any damage. By the time the thunder is heard the lightning stroke is past, perhaps as much as several seconds. Since sound travels at about 1,100 feet per second in air, it is seen that if the first sound of thunder takes 10 seconds to reach the ear, the lightning was more than 2 miles away.

DESIRABILITY OF PROTECTION

In areas where thunderstorms are frequent and intense, the protection of all important farm buildings and other exposed structures is

recommended, especially when human or valuable animal life is involved. Only standardized equipment that has been approved by the Underwriters Laboratories should be used. It should conform to the rules and specifications for both materials and methods of installation contained in the Code for Protection against Lightning.[2]

Even though insurance reimburses the owner for the money value of property lost in a lightning fire, the destruction represents a waste, and a long period of time may elapse before a building can be replaced. Furthermore, the contents may not have been insured and a year's labor may be lost. Apart from the safeguarding of property, the installation of an adequate protective system is fully justified by the relief it affords many people who suffer an exaggerated fear during thunderstorms.

The statement that lightning conductors draw lightning is true only to a slight extent. A stroke of lightning near a rodded building would very likely be diverted to the conductors. It would, however, pass to ground without harming the building. On the other hand, if the building were unrodded, the stroke would probably cause damage.

A system of grounded conductors and carefully placed air terminals on a protected building serves in the main to provide multiple paths for the lightning current so that harm to the building and contents is prevented or greatly minimized when a direct, disruptive stroke of lightning to the building takes place.

METHODS AND MATERIALS USED IN PROTECTION FROM LIGHTNING

KIND OF EQUIPMENT TO CHOOSE

The choice of equipment is determined mainly by: (1) The value of the building, (2) the nature and value of its contents, (3) the frequency and intensity of thunderstorms, (4) the requirements for protection of human or animal life, and (5) the amount of money available for investment in protection. As a rule dwellings, barns, and other structures representing a considerable investment or housing valuable or flammable material should be rodded in as effective and durable a manner as possible, especially in regions of frequent and violent thunderstorms.

The rules governing installations given in this bulletin are based on the Code for Protection Against Lightning. These rules, with due regard to costs, should be followed when choosing serviceable equipment. Some buildings do not need protection because of their position with respect to taller and more important structures nearby. It is in such situations that the experience and know-how of a professional lightning-protection man is almost indispensable for making proper decisions as to materials and methods. To cut costs, ornaments such as wind vanes should be omitted, since they do not add to the protection, and if improperly designed and installed they may lessen the stability of the air terminals to which they are usually attached.

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[2] National Bureau of Standards. Code for protection against lightning. Natl. Bur. Standards Handb. H40, 99 pp., illus. 1945.

This handbook may be purchased from the Supt. of Documents, Government Printing Office, Washington 25, D. C. Do not send stamps. It is referred to in this bulletin as Code.

Choose equipment to suit your needs. For general utility under nearly all conditions a copper cable or steel rod is preferable. The latter should be carefully jointed and heavily galvanized.

MATERIALS

The materials or fittings used in protecting a building from lightning may be classified under four heads: (1) Conductors or rods; (2) fasteners for conductors; (3) air terminals, including points and elevation rods or tubes and their supports; and (4) ground connections. To avoid electrolytic corrosion the use of two different metals in the same system should as a rule be avoided, especially if moisture is continually present. If two kinds of metal are placed in contact, the connecting link must be of a type that drains readily after rains or snows, thus reducing corrosion to a minimum.

Durability should be the principal concern in choosing the kind of metal to be used. Pure copper resists corrosion almost indefinitely if exposed to air free from gases containing nitric acid or if buried in soil relatively free from ammonia. Thoroughly galvanized steel also resists corrosion for long periods both in air and soil, but it should not be used where well-galvanized iron or steel does not last long, as in seacoast areas where salt spray is prevalent. Wrought iron is also good. Copper-cable installations are usually preferable; the underground conductors at least should be copper. Copper, iron, or aluminum in the forms and dimensions customarily employed possess sufficient mechanical strength and electrical conductivity.

CONDUCTORS

Several kinds of lightning conductors are shown in figure 3. For all practical purposes the copper cable and the star-section steel rod are the best forms of conductors, although there is no serious objection to the use of a tubular conductor. Cable has the advantage of being flexible and therefore easily installed. Since it may be purchased in lengths as great as 1,000 feet, it need have few joints. If too loosely woven, it may not have the required stiffness.

Steel rods make a mechanically strong, durable job. The 10-foot lengths must be screwed together and special tools are required for making bends. Recently aluminum conductor has come into use. Its use will be permitted by the next edition of the code to be published soon, but care must be taken to avoid electrolytic corrosion where the aluminum comes in contact with iron, copper, or zinc. Such contacts should be avoided if possible. According to the code the use of copper, copper-covered steel, or copper-alloy fittings is not permissible when an aluminum conductor is used. Aluminum should not be used for ground connections, since it corrodes in the ground. Copper should be used in such exposures. The light weight and flexibility of aluminum, however, are advantageous for conductors above ground.

According to the code, copper cable or other copper conductor must have a weight of not less than 3 ounces per foot, galvanized steel about 5 ounces, and aluminum about 1.6 ounces. Excellent lightning conductors are made with galvanized steel or iron or steel with an integral copper coating.

Painting conductors above ground does not detract from the value

of the conductor, and their life may be increased by painting as soon as serious corrosion is in evidence. Aluminum conductors and fittings used in seacoast areas, subject to the corrosive action of salt air, should be protected by painting or other means immediately upon installation. Conductors forming the earth connection should not be painted, since the electrical resistance of the ground is thereby much increased, whereas the resistance should be as low as practicable.

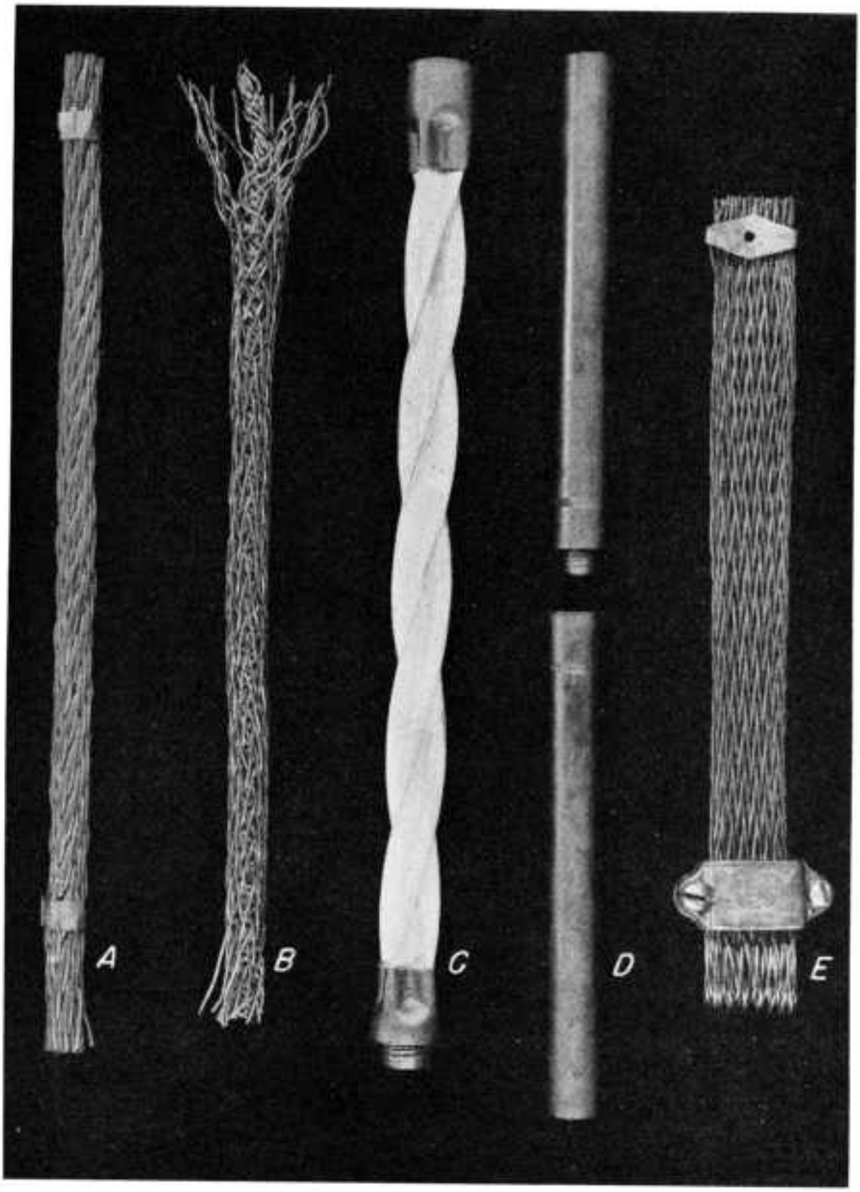

Figure 3.—Lightning conductors: *A*, Tight-twisted copper cable one-half inch in diameter; *B*, loose-weave copper cable; *C*, star-section steel rod, heavily galvanized; *D*, copper tube; *E*, flat copper cable, 1/8 by 1 inch.

FASTENERS

A variety of fasteners for securing the conductor to various parts of a building is shown in figure 4. The kind chosen depends largely upon the construction of the roof and walls of the building, the kind

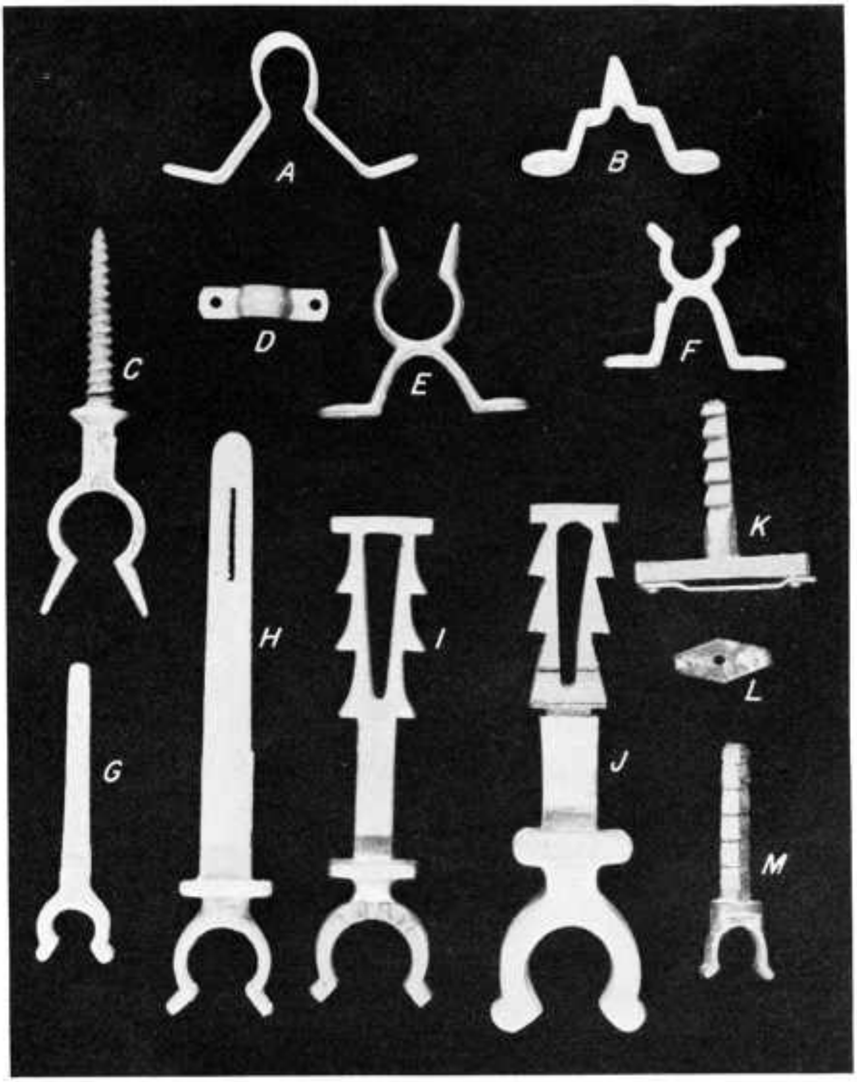

Figure 4.—Conductor fasteners: *A*, Loop fasteners for cable, also used for star-section rod; *B*, fastener for star-section steel rod laid flat on surface of building; *C*, screw fastener for cable, also used for star-section rod; *D*, strap for cable laid flat on surface; *E* and *F*, "disperser" attachments for rod and cable; *G*, *H*, *I*, *J*, *K*, and *M*, various forms of fasteners used with cable and star-section rod adapted to masonry or concrete. *J*, Chimney fastener coated with lead to protect it from corrosion; and *K* and *L*, fasteners used with flat copper cable (fig. 3, *E*), the latter fastener being secured with copper nails. *A*, *B*, *D*, *E*, and *F*, Fasteners usually secured to the surface with galvanized nails (screws would make a better job).

of installation, and whether the fasteners are to be put in place while the building is being erected or attached after it is finished. Strap fasteners (fig. 4, *D*) held by galvanized or copper-plated nails and occasionally by screws, are extensively used for attaching conductors to wooden surfaces. Judging from the condition of the fastening after long periods of time, they are satisfactory. For general all-around usefulness with round-section conductors, however, the screw fasteners (fig. 4, *C*) are apparently excellent. They are adaptable to any kind of surface. Their attachment to a roof is illustrated in figure 5. They are screwed directly into the wood or used with expan-

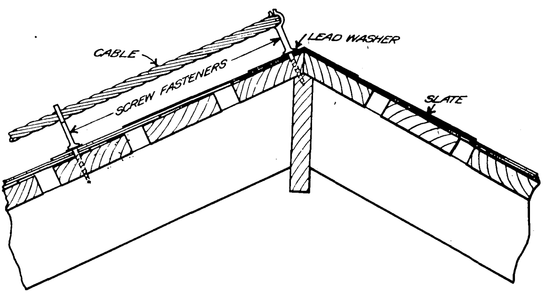

Figure 5.—**Use of screw fasteners on shingle, metal, or slate roofs.**

sion sockets in masonry walls. These fasteners are not easily loosened after being screwed into place. They are strong and not subject to corrosion. The cable is easily inserted in the open loop and held securely by squeezing the two prongs of the fastener together with pliers.

The other types of fasteners shown are all serviceable. Their use is mentioned in the legend for figure 4.

AIR TERMINALS

Complete air terminals are usually made as shown in figures 6, 7, and 8. They usually consist of three parts: (1) The point, (2) the elevation rod or vertical conductor, to the upper end of which the point is attached, and (3) the tripod support. Sometimes only a point (not less than 10 inches high), footed direct to the roof con-

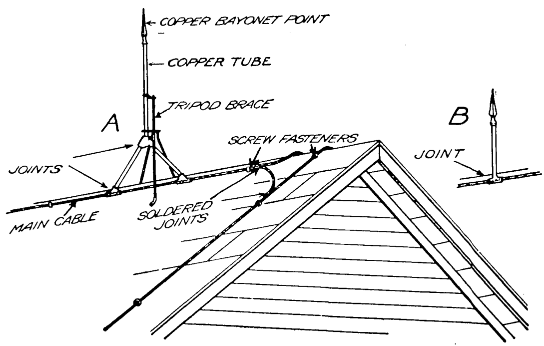

Figure 6.—Copper-tube air terminal with iron-tripod support. *A*, Inverted Y-connection of elevation rod to main conductor; *B*, customary T-connection to main conductor.

ductor so as to be inconspicuous, is used. The points are the objects in the protective conducting system that receive the lightning discharge, thus preventing damage to the building itself.

When the elevation is short, as shown in figure 6, *B*, erect position of the air terminal is maintained by firm attachment to the horizontal conductor on the roof, but, for heights of 18 inches to 5 feet galvanized-iron tripod supports are often used (fig. 6, *A*.). The supports are frequently attached to the roof by galvanized nails. Screws are better, and where ready access may be had to the underside of the roof a firm attachment can be obtained by the use of bolts (fig. 9). Air terminals erected as described and illustrated are seldom damaged by wind or by snow and ice storms.

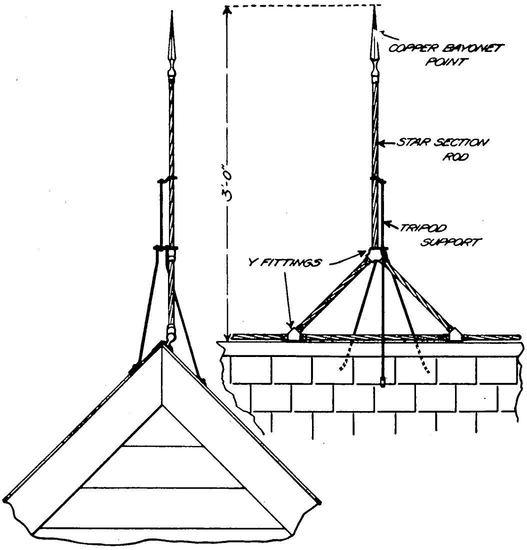

Figure 7.—**Air terminals formed of star-section steel rod.**

Several kinds of points for air terminals are shown in figure 8. The copper tube or so-called shell point is extensively used with the copper-tube elevation rod. When the point proper is solid for 3 inches or more from the end and the walls of the tube are not less than No. 20 (0.032 inch) gage in thickness, they are sufficiently heavy to withstand the fusing effect of severe strokes. An alternative is the copper bayonet point, a solid, substantial fitting that is generally preferable. The bayonet point is also used with star-section steel elevation rods. Multiple points may be used without objection when the individual points are sufficiently heavy, but one large-size heavy point is enough for one air terminal and is less expensive. Where conditions causing corrosion are severe, for example at the top of chimneys, points and their associated conductors and fasteners if within 25 feet of the source of corrosive gases or fumes are lead covered.

The elevation rod may be attached satisfactorily to the main conductor in several ways, as indicated in figures 6, 7. The lower ends of tube elevation rods are so shaped that they can encircle a copper

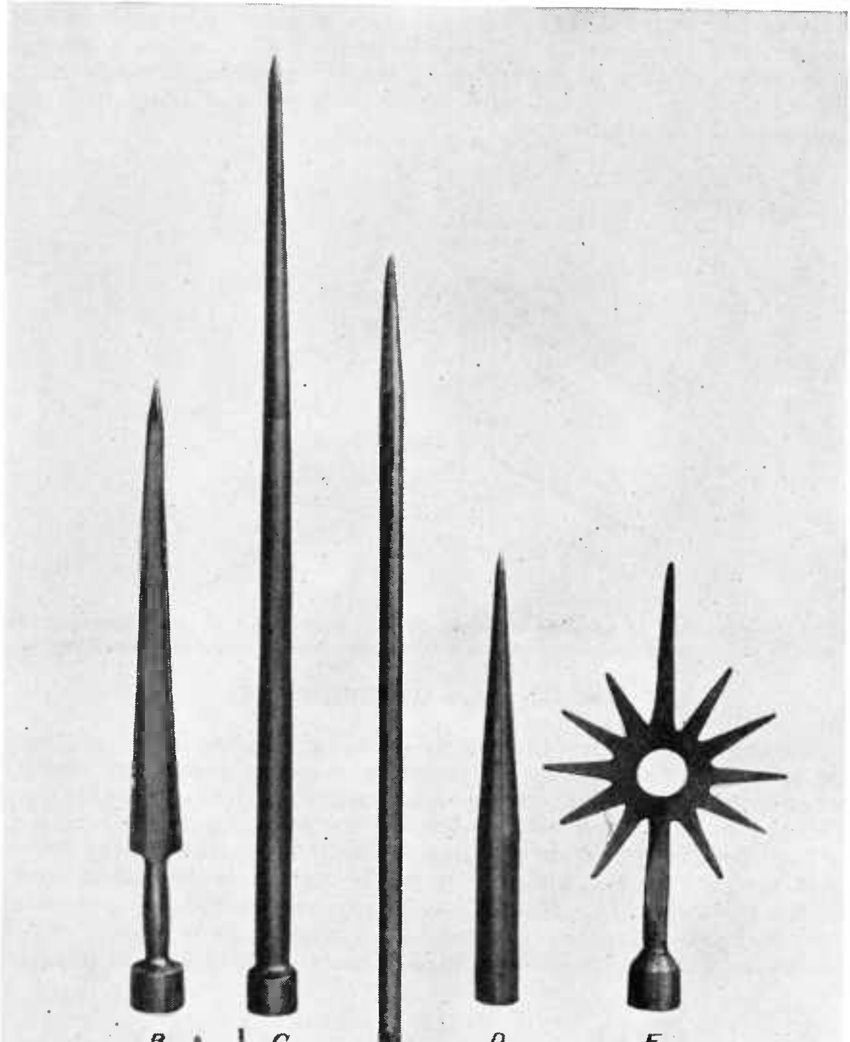

Figure 8.—*A*, Complete air terminal of the short-top variety, consisting of an all-copper, saddle-type brace with a copper-bronze connector to engage the ridge conductor. The point proper is three-eighths inch in diameter and made of solid copper bar with nickel tip. *B*, Copper-bronze, nickel bayonet point, 10½ inches long. *C*, Copper-bronze, nickel-tipped point, 16½ inches long. *D*, Copper shell point, nickel-tipped, mounted on copper-tube air terminals five-eighths inch in diameter. *E*, Copper-bronze crown point. Points *B*, *C*, and *E* can also be used with the saddle-type brace (*A*) and may be used either with star-section or with copper-cable rod.

cable and be squeezed firmly into contact with it without the use of solder. A T-connector, designed to be inserted into the tube and made with finger grip that firmly engages the cable, may also be used. Star-section rods are provided with screw fittings for contact with the flanges of the conductor.

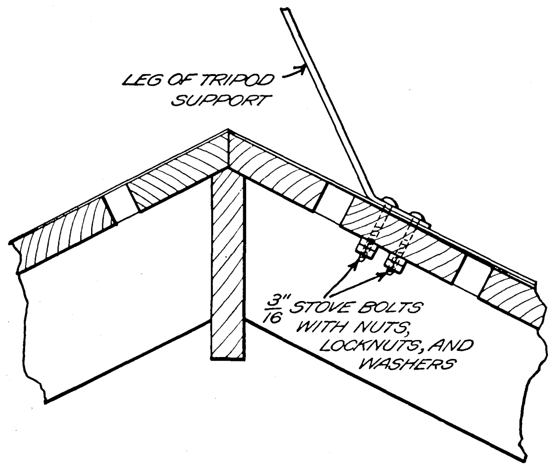

Figure 9.—A method of attaching leg of air terminal support to roof, where access can be had to underside of roof. Iron tripods are, however, usually nailed or screwed down.

INSTALLATION OF EQUIPMENT

Sketch plans and elevations of the building to be protected, with the air terminals, conductors, and grounds shown thereon, are usually necessary when specifications are submitted to bidders. Specifications for bids should include the requirement for written guaranties: First, by the manufacturer covering the durability and quality of the equipment used in rodding; and second, by the installing contractor covering his workmanship. Provisions for periodic inspections and maintenance following the completed job should be made a part of the contract. Figures 10, 11, 12, and 13 are examples of typical installa-

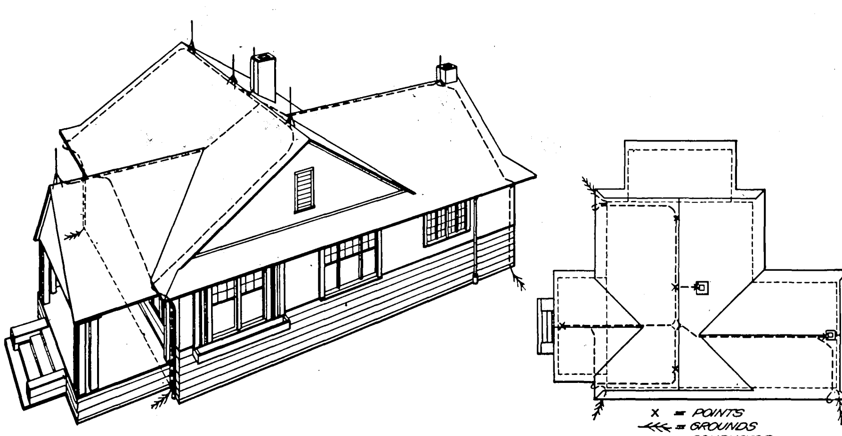

Figure 10.—Method of installing lightning conductors to protect a small, 1-story farmhouse.

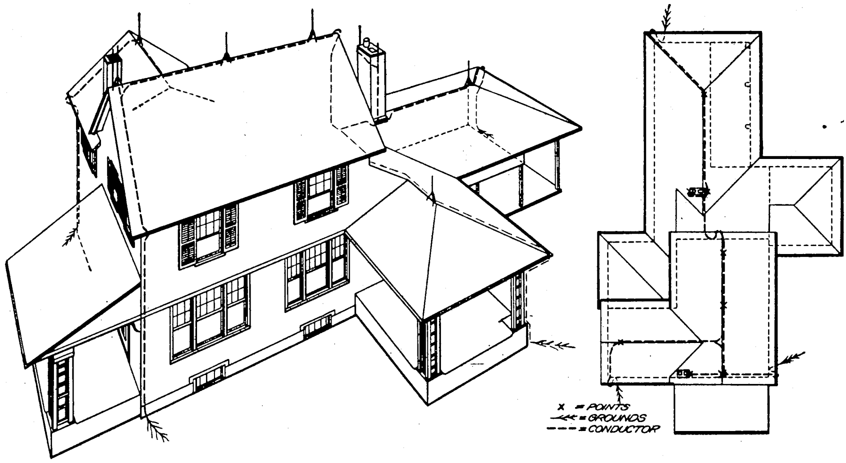

Figure 11.—**Method of installing lightning conductors to protect a large, 2-story farmhouse, having an L and 2 porches. Note method of carrying conductor around the chimney.**

tions to serve as guides to the prospective purchaser of equipment. Methods to be followed in installing the various parts of the equipment are given in detail below.

PLACING CONDUCTORS

Conductors should be coursed over the building as far as possible in straight runs to form approximately an enclosing network. Avoid unnecessary and sharp bends. Changes in direction are made, if practicable, in curves of large radius. Abrupt changes in the direction of the conductor may result in arcing of the electric current across the short bends. The manner of coursing conductors around chimneys and over the edge of a roof is shown in figure 14. As a general

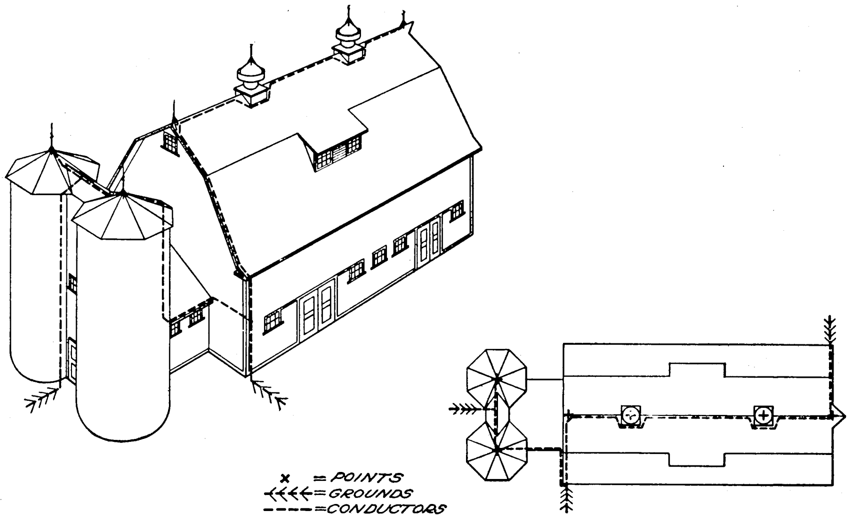

Figure 12.—**Method of installing lightning conductors to protect silos and barn.**

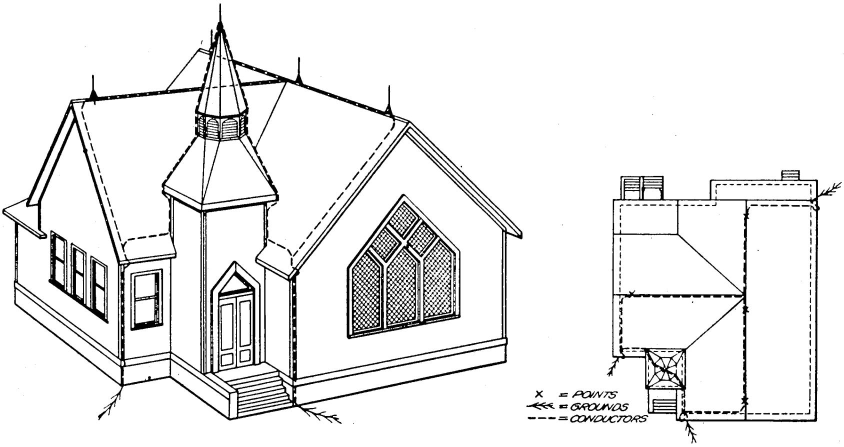

***Figure 13.*—Method of installing lightning conductors to protect a church building.**

rule conductors shall everywhere keep a downward or approximately horizontal course.

Where end-to-end joints of the conductors are necessary, suitable solderless connectors may be used. When copper cable is used joints may be made with fittings of rugged construction that will permanently engage and connect the parts. The various methods are illustrated and described in figures 15 and 16. Joints are almost entirely avoided in copper-cable installations, since the cable often can be run over a building from one corner to another diagonally opposite without a break. All joints must be mechanically strong and of low resistance without dependence upon the use of solder. Solder may be added to protect the joint from corrosion.

Fasteners for securing the conductors to the walls and roof of a building should be spaced generally not more than 4 feet apart, the spacing depending somewhat on the kind of conductor and on the construction of the building. The principal aim is to obtain a neat and durable job with the conductor firmly held in place. Holes through the roof made by the fastener screws or nails must be made watertight.

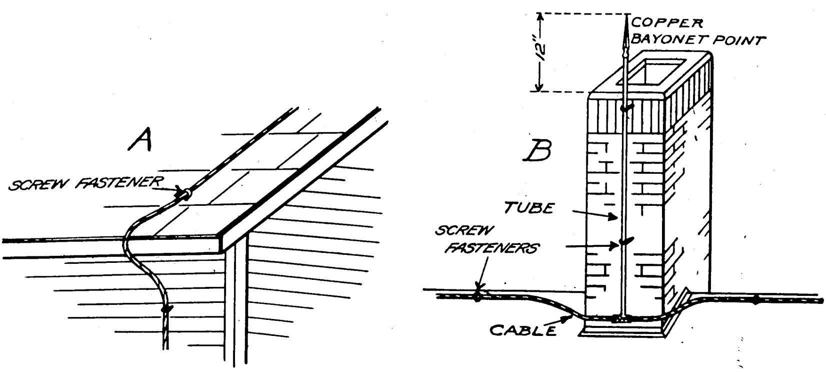

***Figure 14.*—*A,* Bends or loops of conductor over edge of roof; *B,* chimney air terminal and connection to main conductor.**

The locations of air terminals should be carefully chosen, and plans should be made for their placement on elevated and upward-projecting parts of the building, such as chimneys, peaks, towers, gable roofs, ventilators, ridges, and dormers. The maximum spacing is 25 feet

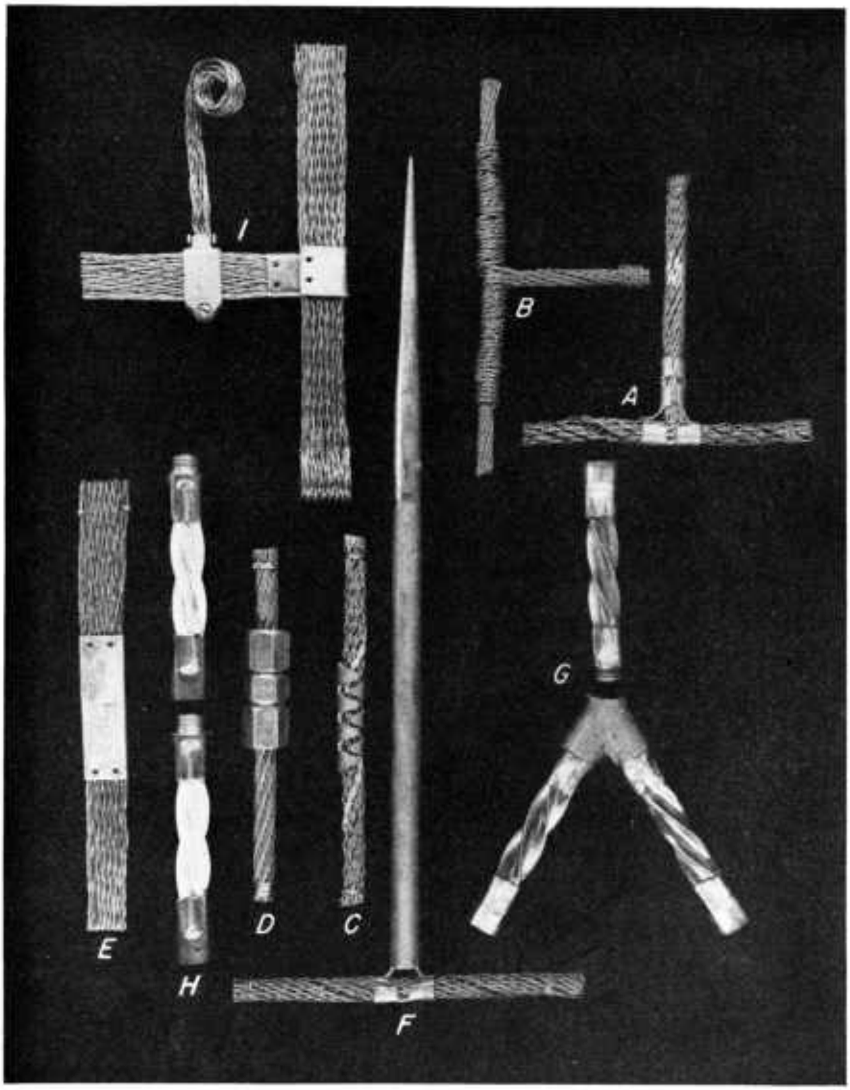

Figure 15.—Conductor joints and air-terminal connections to main conductor: *A*, Right-angled joint of copper cable, using a copper fitting; *B*, joint of copper cable made by wrapping strands of one cable about the other, the joint preferably soldered; *C*, *D*, and *E*, end-to-end joints of copper cable (*C*, copper fitting wrapped about the cable; *D*, solderless connector; *E*, flattened copper tube with the cable ends inserted therein and all held together by nails driven through holes in tube to surface to which conductor is attached); *F*, right-angled joint of tubular air terminal to main conductor of copper cable; G and *H*, Y-branch and end-to-end joints of star-section steel rod; *I*, right-angled joint of flat copper cable and fitting for attachment of cable used for cross connection.

along the edges of flat roofs and the ridges of hip roofs when the air-terminal height is from 24 to 60 inches. When the height is less than 24 inches the spacing should not exceed 20 feet. On extensive flat roofs it is necessary to erect air terminals along the edge of the roof to form an enclosing loop and also at points within. The inside terminals should be not more than 50 feet apart. All must be connected by a network of conductors.

Such salient structures as steeples, silos, and towers require one or more air terminals, depending on their construction, and two down conductors. One of the down conductors should go directly to a separate ground, but the other may be connected to one of the grounds of the main system of conductors. (See fig. 12 for the rodding of silos.) Metallic masses in steeples and towers should be cross-connected to the rods as outlined on page 23.

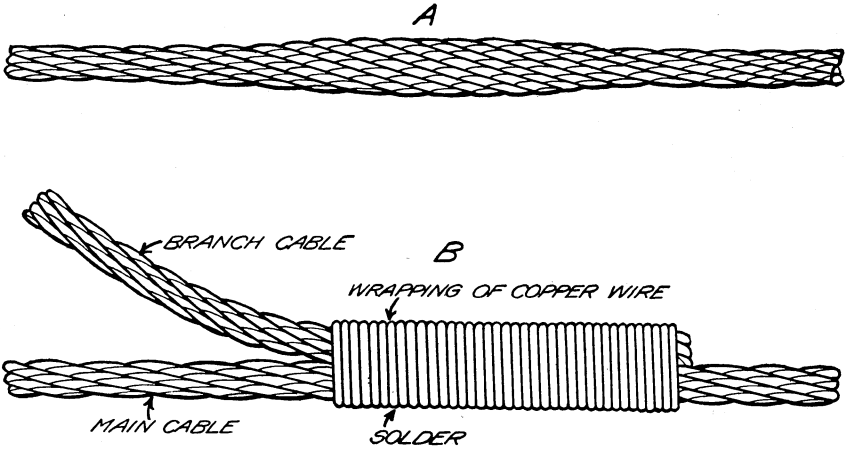

Figure 16.—Other methods of forming conductor joints: A, End-to-end joints of copper cable; B, side branches.

The air terminal should extend to a height of not more than 60 inches nor less than 10 inches above ridges, gables, or flat roofs. A height of 10 to 14 inches above the top of an ordinary chimney is sufficient as a rule, and short air terminals are all that are required on pointed parts of a building, such as peaks and steeples. In general the height of air terminals depends on the configuration of the roof and the material of which it is made.

CONSTRUCTION OF GROUNDS

The ground connections include the buried plate, the moist earth surrounding the plate, and the conducting rod that forms the electrical path from the down conductor to the earth. Grounding is the most important part of the protective system. Unless the grounds are properly made the efficiency of the system is much reduced. Every care should be taken in constructing the grounds to be sure that the electrical resistance will remain as low as possible or practicable. To obtain the best results (1) the soil in which the metal is placed should be permanently moist; (2) the area of contact between the metal and the soil must be ample, better in excess than not enough, and the elec-

trical resistance should be less than 5 ohms if possible; (3) the metal in the soil must be electrically connected to the down conductor in as permanent a manner as possible; and (4) the metal used in the earth must be of a kind that resists corrosion. Copper, bronze, and cast iron in their commercial purity generally fulfill this condition, and heavily galvanized or copper-clad steel is also satisfactory.

Reliable grounding generally requires that the ground connection be located in permanently moist earth. The moisture content and character of the soil in which the ground is to be made should therefore be carefully determined before the kind of ground connection is selected. The dryness or wetness of the season at the time of inspection should be taken into consideration. The soil should not be dry even during drought. Occasionally it will be impracticable to reach permanently moist earth because of rocky soil. It is then necessary to resort to the more expensive alternative of increasing the area of the ground connection by extending it horizontally and radially from the building as far beneath the surface as is practicable or economical. Occasionally a difficulty of this kind is met by burying a copper conductor in a trench extending entirely around the building and joining this ground connection to all of the down conductors on the building. Another alternative is to increase the number of grounds of the usual type.

The number and location of the grounds are also important. In general there should be not less than two and they should be spaced as far apart as practicable and more or less equally distant from each other. Wherever possible connections should also be made to underground water pipes. Soil or chemical substances that will corrode the ground connection should be avoided. The moisture conditions of the soil may not be the same at different places about the building. The more moist locations should be given preference.

There must be two paths for a lightning discharge from every air terminal to ground. Additional down conductors are required where necessary to avoid dead-end branches more than 16 feet in length [3]; that is, if an air terminal is set more than 16 feet in a horizontal direction from a roof conductor, it must be connected not only to the roof conductor but also to ground by means of one or more additional conductors. Ground connections should extend below and out from the foundation walls of a building to avoid damage to the walls in case of a stroke.

Grounds may be constructed in accordance with any of the methods described and illustrated in this bulletin. Connections to water piping where it enters the building generally constitute the best ground available, especially if the water system is large, as in a city or community system. It is perhaps better not to use the piping of individual water systems as ground for lightning protection systems. Where connections may be made to water pipes, they should be made with a good clamp (fig. 17).

A copper plate having an area of about 10 square feet to which the copper down conductor is securely riveted and soldered is shown in figure 18. The thickness of the plate may be one-sixteenth inch, but thicker metal may be used for very long service. Such a ground plate should be buried in earth where there is permanent moisture. Four

[3] See footnote 2, p. 7.

or five inches of charcoal (which is itself a fairly good conductor) broken to pea size should be placed under and on top of the plate. The charcoal has the effect of increasing the area of contact of the ground connection with the earth, thus lowering the electrical resistance. It also absorbs water and therefore assists somewhat in maintaining a moist condition about the plate.

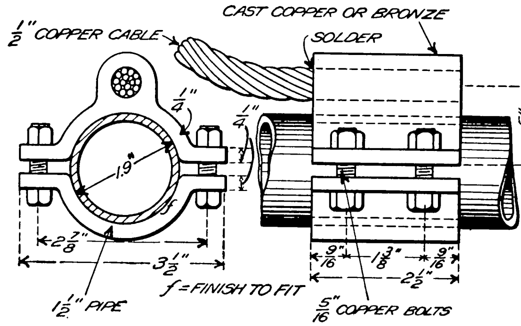

Figure 17.—Clamp for water-pipe ground connection.

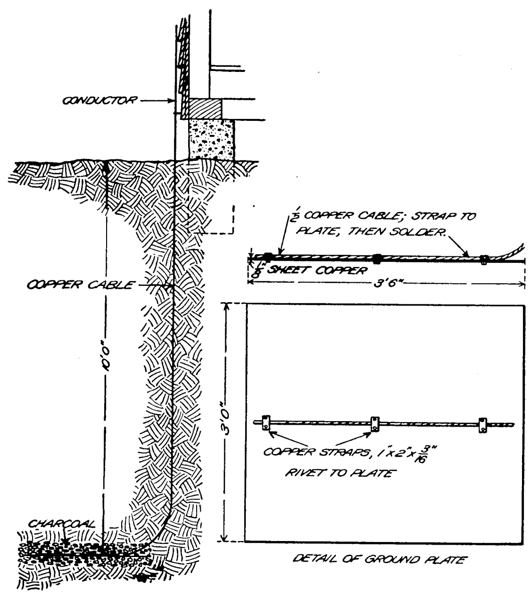

Figure 18.—Copper-plate ground connection.

In deep soils of moist loam over clay, or other similar soils, very satisfactory grounds may be constructed at a small cost by driving the conductor 8 to 10 feet into the soil. It may be easier to place the ground rod if a hole is drilled first. A drill similar to that shown in figure 19 may be used.

There is sometimes danger that a cable conductor will be pulled out of the earth. This may be prevented by attaching a copper plate to the conductor as shown in figure 20.

Where the soil is such that the driving method of grounding is not practicable, some other method must be used. Under no circumstances should an attempt be made to ground the down conductor merely by inserting a short length of its lower end in the earth. There is not enough area of contact of the metal with the soil to provide a satisfactory ground. It is almost certain that the top layers of the soil will dry out at times and thus increase the electrical resistance too much.

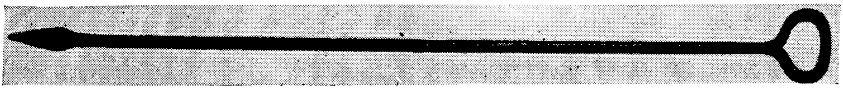

***Figure 19.*—Earth drill for making ground connections by extension of down conductor.**

Where the soil does not permit driving or drilling vertically to a sufficient depth, a satisfactory ground may be constructed by burying a copper cable in a narrow, flat-bottom trench. This trench should extend for some distance away from the foot of the down conductor. The depth may vary. Shallow trenches must be longer than deep ones. For a depth of 5 feet a length of 15 feet would be a fair estimate; decreasing the depth to 4 feet would require about 20 feet of length. Other depths are estimated in a similar manner.

When the trench is dug, the strands of the cable should be spread out and laid along the bottom. The cable should enter the trench in a long bend, as shown in figure 21. The conductivity of the ground

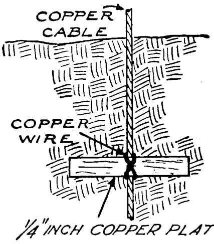

***Figure 20.*—Copper plate attached to cable conductor to prevent its being pulled out of the earth.**

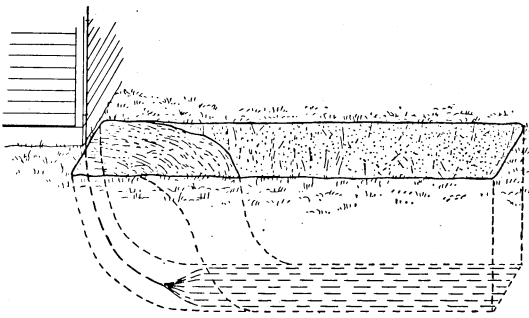

***Figure 21.*—Stranded-cable ground connection.**

connection thus formed may be increased somewhat by embedding the stranded cable in pea-size charcoal, saturating the charcoal with water, and tamping the earth thoroughly as the trench is filled. The resistance may be still further lowered by splicing a second length of cable to the main conductor near the bottom of the trench at the house end. Both the stranded cables should be run to the end of the trench or in separate trenches if desirable. When a single ground connection does not have a sufficiently low electrical resistance, it is quite customary to provide one or more additional driven grounds, all connected at different points along the ground conductor.

Generally it will be necessary to call upon an expert to plan and install the equipment and to furnish the materials needed, but the

methods to be employed should be common knowledge to both parties to the contract. The work should be carefully followed during its progress, particular attention being given to the manner in which the grounds are made. A reputable contractor, however, will guarantee his work, and such a contractor should be given preference. Moreover, he will often follow up his work with periodic inspections in order that any defects may be repaired. The owner should not depend entirely on such service, but should also watch the equipment and prevent its deterioration. Thoroughly reliable protection cannot otherwise be maintained.

INTERCONNECTING AND GROUNDING METALWORK OF BUILDINGS

EXTERIOR METALWORK

All the exterior metal parts of a building of any considerable size, such as roofs, gutters, downspouts, finials, soil or vent pipes, and other metal masses projecting through the roof or the sides of the building above the second floor, should be carefully cross-connected to the lightning-rod system, unless the manner of installing the air terminals or conductors has already placed the metalwork in good electrical contact with the lightning conductors.

It will usually be necessary to make the connections permanent and dependable. Copper wire, stranded cable, or soft-copper strip of No. 20 B. & S. gage from ½ to 1 inch in width may be used. The joints should be clamped and thoroughly soldered. No. 6 gage wire, or its equivalent in a cable, is a satisfactory size for this work. Metal bodies of considerable size should be connected at top and bottom or from the ends to the nearest lightning conductors. Often the conductors are run alongside such metals, and cross-connections can very easily be made. However, if gutters are cross-connected to the conductors and the joints of gutters are soldered to down spouts, no cross-connection of the downspouts to the conductors will be necessary at the upper ends. The lower ends must be grounded, either directly or by connection to nearby down conductors. The conductors used to make the cross connections should be securely attached to the building in a neat and durable manner without being too conspicuous. Where necessary the cross-connections should be protected from mechanical injury.

METAL-COVERED STRUCTURES

Metal-roofed and metal-clad buildings, when properly grounded, usually require little further attention to make them reasonably safe from damage by lightning. The down conductor should be connected to the underside of aluminum roofs. Clamps and fastenings made of aluminum but otherwise similar to those used for copper grounds should be used (fig. 18). Adding air terminals where needed and cross-connecting and grounding interior metalwork completes the installation and brings it into full accordance with standard practice as set forth in the following paragraphs quoted from the Code:

214. Metal-Roofed and Metal-Clad Buildings.

(*a*) Metal in Overlapping Sections.—Buildings which are roofed or roofed and clad with metal in the form of sections insulated from one another, or so applied that they are not in electrical contact, shall be treated in the same manner as are buildings composed of nonconducting materials.

(*b*) Metal Continuous.—When buildings are roofed or roofed and clad with all-metal sheets made electrically continuous by means of an interlocking or other contact, or by bonding, the following modifications may be made:

Air terminals need be provided only on chimneys, ventilators, gables, and other projections, such as are likely to receive and be damaged by a stroke of lightning. Projections that are likely to receive, but not be damaged by, a stroke of lightning need not be provided with air terminals but shall be securely bonded to the roof.

Roof conductors may be dispensed with and elevation rods, if used, connected to the roof by soldered joints, or securely bolted joints, having an area of contact of not less than 3 square inches (19.3 $cm.^2$). If the roof metal is in small sections, connection shall be made to at least four of the sections.

Down conductors shall be connected to the edges of roofs, or to the lower edges of metal siding, by soldered or bolted joints having an area of contact of at least 3 square inches (19.3 cm^2). If the metal is in small sections, connection shall be made to at least four of the sections.

Interconnection of exterior metalwork in a metal-covered building should be carefully done. Although the metal cover may be used in place of the usual lightning conductor for making connections, this should be done only when the cover is continuously conducting and well grounded.

INTERIOR METALWORK

Pipes of all kinds and other metal bodies extending for a considerable length parallel to the lightning conductors should be connected to a conductor at one end and grounded at the other within the building or connected to another conductor on the exterior, provided the distance from the conductor to the interior metalwork is less than 6 feet, or more than 6 feet if the mass or extent of metal is great. Ordinarily when the distance exceeds 6 feet, grounding only is necessary. The methods used in making such cross-connections are similar to those described for exterior metalwork. Ground connections within a building can frequently be made to water piping, using a form of clamp similar to that illustrated in figure 17. Moderately small masses of metal may be grounded only, but the extent to which cross-connections should be carried is governed by the nature of the contents of the building and its construction. Metalwork in barns, especially those containing unbaled hay or other easily ignited materials, should be so cross-connected as to make induced discharges from the metalwork to ground through these materials impossible. Hay and litter-carrier tracks inside buildings, metal feed chutes, and metal ventilation ducts are examples of such metalwork.

Where possible, lightning conductors should be placed more than 6 feet from any part of metal stanchions and exposed water pipes. The stanchions should be grounded at both ends separately from the lightning protection grounds. Bond the water and milking-machine pipes to the metal stanchion at both ends. Ground the water pipe at both ends of the stanchion to the gutter drain or to driven ground rods. Additional protection will be afforded if the metal stanchion pipes are bonded directly to the cast-iron gutter drain pipe.

WINDMILLS AND OTHER STEEL TOWERS

Towers used to support windmills ordinarily do not require any special protection against lightning except for grounding, since they are constructed of steel. Wooden water tanks placed upon steel towers should, however, be surmounted by one or more air terminals con-

nected to the metalwork of the tower. Pump and tank towers must be well grounded by one of the methods already described. The same treatment should be given flag, signal, and bell towers built of steel.

OVERHEAD WIRES

Overhead wires entering a building for electric light and power, radio, or telephone circuits occasionally provide a path for lightning to enter the building. Properly installed lightning arresters placed as near as possible to the point of entrance of the wires to the building provide a reasonably effective safeguard to the building and the connected appliances. The ground connection for the wires should be well made and separate from the lightning-rod grounds. It is common practice to protect telephone circuits. Fortunately most radio receivers now have built-in aerials but those connected to outside aerials require lightning arresters. Installations should be made according to the rules for protecting telephone and radio circuits from lightning, as given in the National Electrical Code.[4]

A good general rule with respect to any incoming wire is to keep it 6 feet or more away from grounded lightning conductors. Arresters for such wires should be grounded separately.

Any overhead wire leading into a building increases the risk of damage from lightning unless it is properly protected. Overhead wires strung from one building to another should have grounded lightning arresters at their point of entrance to each building if maximum protection is desired. Interior wiring will be satisfactory if installed in accordance with the National Electrical Code.

Electric light and power lines from a distant central station are protected from lightning by the company furnishing the service. The degree of protection provided varies according to what the company deems to be sufficient, depending in part on the frequency and intensity of thunderstorms. It is not customary to place lightning arresters at the point of entrance of the service wires to the building. However, when the grounded transformer is located at a considerable distance from the building and the secondary or low-potential circuit to the building is perhaps 200 feet or more in length, an additional measure of safety to the building and line will be obtained by installing arresters at the building end. The question of such protection should be taken up with the electric service company. The length of the secondary circuit and the degree of severity of the electrical storms in the vicinity, as evidenced by the frequency of fires started by lightning running in on wires, should be considered.

The rules covering the installation of the grounding switch and lightning arrester for aerials for radio receivers and their lead-in wires are given in the National Electrical Code. An outside aerial strung from an elevated part of the house to a distant support obviously may be struck at any point of its length, in which event the current would ground through the switch or the arrester. The usual No. 14 gage aerial and lead-in wire, with the switch and ground connections, are insufficient to carry a heavy lightning current. The wire would most likely be melted or volatilized and side flashes would

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[4] National Board of Fire Underwriters, 85 John Street, New York 7, N. Y.

likely occur to whatever grounded conductors are nearest the path of discharge. The need for a thorough protection of buildings under these conditions, particularly of farm buildings where the lightning hazard is greatest, should be apparent. If a pole of considerable height is used to anchor the house end of the aerial, it would be advisable to place an air terminal on it and connect the air terminal to the nearest lightning conductor or to the ground. If a metal pole is used, it should be grounded. The aerial of a television set is treated the same as the aerial of any other radio receiver.

RODDING SILOS

Inspections of lightning-rod installations have frequently shown that silos have been built without attention to their relation to the lightning rods already in place. These structures are usually close to the barn and should be tied into its rodding. Good practice generally requires a separate ground and a second connection from the air terminals on the silo to the lightning rods on the barn (fig. 12).

PROTECTION OF FLAGPOLES

Wooden flagpoles are very frequently struck by lightning and considerably damaged or rendered useless. A flagpole, however, can be almost completely protected from such damage by surmounting the pole with an air terminal, essentially as shown in figure 22. The down conductor should be attached to the pole with suitable fasteners and connected to a separate ground when the pole stands by itself in the open, or should be joined to the lightning-rod system on the building when the pole is erected on the roof. Metal flagpoles should be grounded.

PROTECTION OF TREES

Big trees near a dwelling are usually valuable, and if it is desired to protect them from lightning the larger ones particularly should be rodded. One or more air terminals should be placed in the top of each tree, but not so high as to be insecure, and should be grounded through one or two down conductors, the number depending on the size of the tree (fig. 23). Screw fasteners with long shanks are more desirable than staples for holding the down conductors in place along the tree trunk. It is desirable to have separate grounds constructed at the foot of the trees. If, however, the tree is conveniently close to a building one of the grounds provided for the conductors on the building may be used. In order that a lightning discharge shall not damage the root system of the tree, it is generally advisable to construct shallow grounds, essentially as described in the section on stranded cable grounds (p. 21). They should extend radially 25 feet or more from the tree, depending on the extent of the root system. The growth of the trees will make it difficult at times to maintain the rodding. Its extension, partial renewal, or repair therefore will be needed occasionally, more particularly on the younger trees but less so on the older trees, which change but little from year to year and are probably the largest and most valuable of a group to be protected. Trees which overhang a rodded building should be rodded. The disruptive effect of a particularly violent lightning stroke is shown in figure 24.

Occasionally it will be necessary to rod isolated or small groups of shade trees under which stock congregate. It would be advisable, however, to form the ground connections by extending the down conductors into the earth, not vertically, but outward at some considerable angle, about 30°. The down conductor must be protected from injury by the stock by providing some suitable barrier about the foot of the tree. Where there is a small group of trees, only a few of the tallest

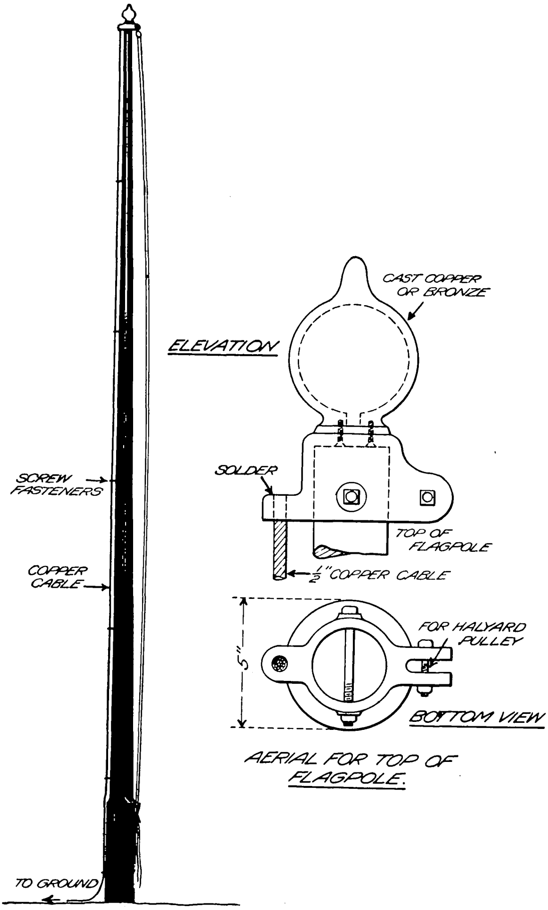

Figure 22.—**Protection of wooden flagpole.**

require rodding. If a grove of trees is available for the stock, it may be advisable to remove isolated trees from the pasture or prevent the animals from using them. The down conductor and grounding terminals should, where possible, be on the side of the tree outside the pasture.

PROTECTION OF LIVESTOCK

Livestock is frequently injured or killed by being in contact with or close to an ungrounded wire fence struck by lightning. To avoid this danger, the fence should be effectively grounded at intervals of

about 150 feet, according to the conductivity or effectiveness of the grounds. A serviceable ground connection may be had by driving a piece of ½- or ¾-inch galvanized-iron pipe or ½-inch copper-coated or galvanized rod about 5 feet into the earth alongside the wooden fence post. The upper end should extend a few inches above the top

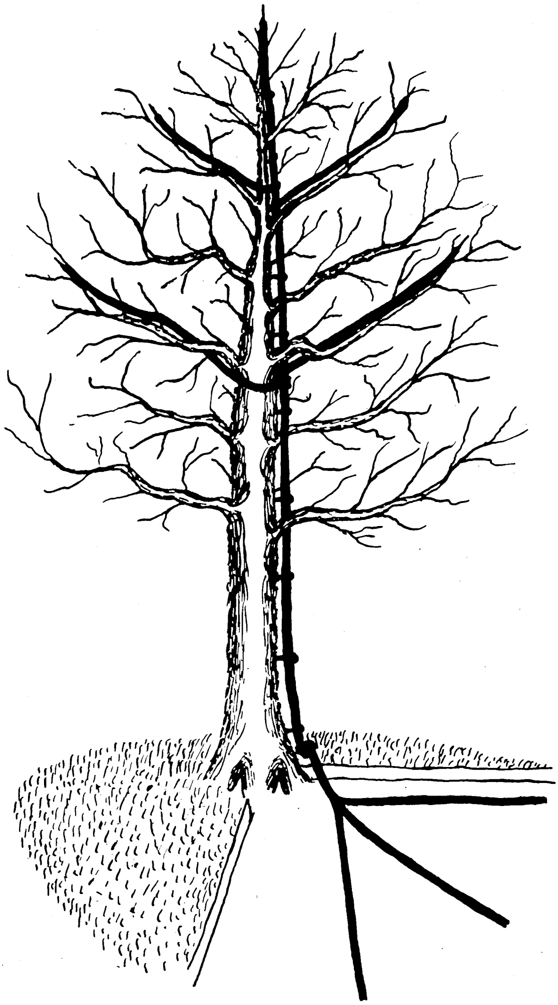

***Figure 23.*—Protection of tree from damage by lightning. The down conductor is attached by means of fasteners that support it an inch or two away from the tree. The rodding for a tree of ordinary size will seldom require four branches. A separate ground terminal is used so that it will not necessarily be pulled up by mechanical damage to the down conductor.**

of the post, and each fence wire should be securely attached to this pipe or rod (fig. 25, *A*). The pipe or rod may be fastened to the post with pipe straps and pressed into contact with the fence wire. Steel fence posts usually provide satisfactory grounds in themselves. A post made of angle iron 1¼ by 1¼ by ⅛-inch in section is shown

in figure 25, *B*. An all-metal fence does not ordinarily require separate grounding, especially if some of the posts are extra long and extend well into the earth and are not set in concrete.

Lightning does not necessarily have to strike the fence. It may strike a tree to which the fence is fastened. It may even strike something not attached to the fence, such as a telephone line. An induced voltage wave may follow the fence from such a stroke of lightning and be dangerous to animals or people standing near. It is a good idea to ground fence wires that run for some distance under power lines.

SPECIFICATIONS FOR INSTALLATION OF EQUIPMENT

Two sets of specifications for the installation of equipment are given. These specifications conform to the principles set forth in this bulletin,

Figure 24.—Effect of lightning stroke on white oak tree near Olney, Md., May 1945.

to the Code for Protection Against Lightning, and to the rules given in the National Electrical Code. They are general in character, and intended only to form the basis or outline for preparing a contract or a request for bids. Such further details as are necessary to care for the particular installation in hand may be added.

COPPER-CABLE CONDUCTORS

Conductors.—Cable of commercially pure copper weighing not less than 3 ounces per foot shall be used. The size of any individual wire in the cable shall not be less than No. 17 B. & S. gage (0.045 inch diameter). The cable shall be coursed as directly as possible over the building, with no sharp bends or loops and in such a man-

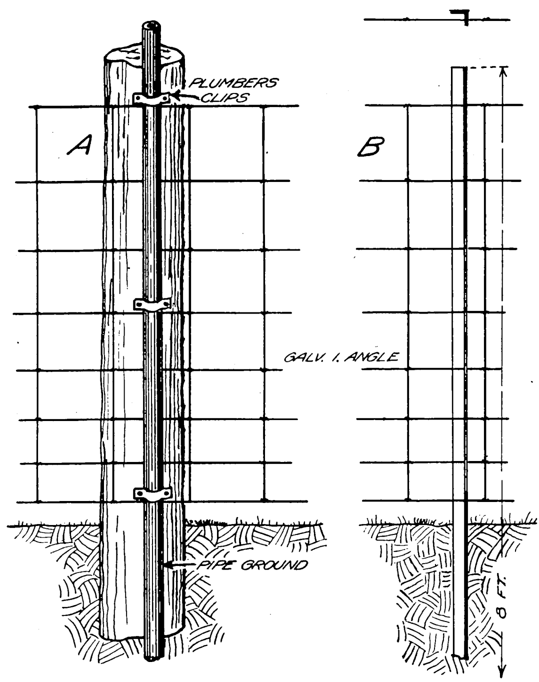

Figure 25.—Grounding of wire fencing: *A*, Fencing with wooden posts; *B*, posts of galvanized angle iron.

ner as to connect each air terminal to all the others. End-to-end joints of the conductor shall be avoided, if practicable, but if necessary the strands at the cut ends will be interwoven for a distance of 5 or 6 inches and carefully soldered or joined by means of solderless connectors of approved type (figs. 15 and 16). Branch conductors from the main cable will be wrapped and soldered or solderless connectors of approved type used.

Cable fasteners.—Bronze or heavily galvanized malleable-iron screw fasteners shall be used (fig. 4, *C*). The fasteners shall be spaced not more than 4 feet apart and screwed directly into wooden walls and roofs. Lead expansion shields shall be used for masonry.

Holes through the roof shall be made watertight by means of elastic roof cement.

Air terminals.—Details of the location of the air terminals are shown in figures 10, 11, 12 and 13. Tube elevation rods shall be used with an inverted **Y**-connection to the main conductor. The walls of the tubing shall be not less than No. 20 gage (0.032 inch) in thickness.

Solid copper, bayonet air terminal points shall be used.

Air terminals shall be placed above ridges, gables, and flat roofs, and above the tops of chimneys, peaks, and pointed parts of the building.

Galvanized-iron or copper tripod supports for air terminals that are 24 inches high or higher shall be furnished and installed, and they shall be fastened to the roof with galvanized-iron screws, through bolts, or expansion screws, as the case requires. When through bolts are used, a lock nut shall be provided or the end of the bolt upset to prevent loss of nut.

Ground connections.—The location of the grounds and down conductors shall conform to the sketches accompanying these specifications. (Builder or owner to prepare sketches.) Grounds shall be made by driving a ground rod to permanent moisture (8 to 10 feet), by drilling and then inserting the grounding rod into the hole thus formed, or by means of buried copper plate or stranded cable.

The down conductor shall be protected against injury by stock or other causes by surrounding it with a substantial guard at the places designated.

Interconnecting and grounding of metalwork.—The gutters and downspouts shall be cross-connected, with suitable clamps, to the lightning conductors, using No. 6 B. & S. gage copper wire or its equal. The gutters shall be connected at each end to the downspouts by soldering or otherwise, and the lower ends of all downspouts shall be either connected to a lightning conductor or separately grounded.

Pipes and other metalwork within the building that extend for a considerable distance parallel to the lightning conductors and that at any point come within 6 feet of the conductor shall be connected to it at one end, and grounded within the building at the other end. No. 6 copper wire or its equal shall be used and the joints clamped. Small masses of metal in the barns shall be grounded to prevent sparking from induction; those in the house do not require grounding or cross-connecting.

GALVANIZED-STEEL CONDUCTORS

Conductors.—If galvanized-steel, star-section rod with copper-bronze couplings is used, the rod shall be three-fourths inch in diameter. The conductor shall be run as directly as possible on the building with no sharp bends or loops, and in such manner as to connect each air terminal to all the others. Ten-foot sections of rod shall be used, and end-to-end joints shall be carefully screwed together. Where branches are attached to the main conductor, **Y**-connectors shall be used so that bends of at least 2-foot radius may be formed with the laterals.

Fasteners for conductors.—Copper-bronze or galvanized, malleable-iron screw fasteners or other fasteners of approved design shall be

used (fig. 4, *C*). The fasteners shall be spaced not more than 4 feet apart, and screwed directly into wooden walls and roofs. Lead expansion shields shall be used for masonry and concrete walls.

Holes through the roof made by the fasteners shall be rendered watertight by means of elastic roof cement.

Air terminals.—Details of the location of the air terminals are shown in the illustrations in this bulletin. Star-section elevation rods shall be used with an inverted Y or other approved connection to the main conductor. The diameter of the elevation rod shall be the same as the conductor.

Solid, copper, bayonet air terminal points screwed to the upper end of the elevation rod shall be used (fig. 8).

Air terminals shall be placed above ridges, gables, chimneys, and flat roofs, and shall be not less than 10 inches above the tops of chimneys, peaks, and pointed parts of the building.

Galvanized-iron tripod supports for the air terminals shall be furnished and installed and fastened to the roof with galvanized-iron screws, bolts, or expansion screws, as the case requires. When bolts are used, a lock nut shall be provided or the end of the bolt upset to prevent loss of nut.

Ground connections.—The location of the grounds and down conductors shall conform to the sketches accompanying these specifications. (Builder or owner to prepare sketches.)

Grounds shall be made by driving the ground conductor to permanent moisture (usually about 10 feet) or by drilling, and then inserting the ground conductor into the hole, or by means of buried copper plate or stranded cable.

Interconnecting and grounding of metalwork.—Specifications for copper-cable conductor shall be followed except that No. 6 galvanized-iron telegraph wire, Birmingham wire gage, and galvanized-iron fittings and screws shall be used instead of copper.

GLOSSARY

Air terminal.—The combination of elevation rod and brace or footing placed on upper parts of structures, together with tip or point.

Conductor.—The part of a protective system designed to carry the current of a lightning discharge from air terminal to ground.

Branch conductor.—A conductor that branches off at an angle from a continuous run of conductor.

Cable.—A number of wires twisted or braided to form a conductor.

Copper-clad steel.—Steel with a coating of copper welded to it as distinguished from copper-plated or copper-sheathed material.

Down conductor.—The vertical part of a run of conductor that ends at ground level.

Elevation rod.—The vertical part of conductor in an air terminal.

Fastener.—A device used to secure the conductor to the structure that supports it.

Ground connection.—A buried body of metal with its surrounding soil and a connecting conductor that together serve to bring an object into electrical continuity with the earth.

Metal-clad building.—A building with sides made of or covered with metal.

Metal-roofed building.—A building with a roof made of or covered with metal.

Point.—The pointed piece of metal used at the upper end of the elevation rod to receive a lightning discharge.

Roof conductor.—The part of the conductor above the eaves running along the ridge, parapet, or other part of the roof.

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